

**CLAIMS**

We Claim:

1. A laser apparatus for producing large-area coherent lasing, comprising:

a periodic structure having a top portion and a bottom portion of a  
5 thickness T and having an average refractive index N, said periodic structure being  
configured to produce a photonic mode of a predetermined frequency, said photonic  
mode being separated from a nearest lower frequency photonic mode by a frequency  
greater than determined in accordance with a following expression:  $c/2TN$ , wherein c is  
the speed of light in a vacuum;

10 a light-emitting medium disposed within said periodic structure, said light-  
emitting medium being configured to emit electromagnetic radiation at said  
predetermined frequency; and

variable excitation means, connected to said periodic structure, for  
applying gain to said periodic structure, said gain ranging from a lower gain to a higher  
15 gain and for causing said light-emitting medium to emit electromagnetic radiation in  
accordance with the magnitude of said gain when said gain exceeds a predetermined  
lasing threshold, such that wide-area coherence lasing at said predetermined frequency  
occurs in a direction perpendicular to said layered structure.

20 2. The laser apparatus of claim 1, wherein said photonic mode is one of a  
defect mode and a high frequency band edge mode.

3. The laser apparatus of claim 1, wherein said periodic structure comprises a plurality of dielectric material layers of at least two differing dielectric constants.

4. The laser apparatus of claim 1, wherein said light-emitting medium is composed of a material adapted to emit electromagnetic radiation upon application of an electromagnetic wave thereto, and wherein said variable excitation means comprises an electromagnetic wave source configured to apply said electromagnetic wave to said periodic structure to excite said light-emitting medium to emit electromagnetic radiation.

5. The laser apparatus of claim 4, wherein said electromagnetic wave source is one of: a laser, a flash lamp, focused sunlight, a light-emitting diode, and an electrically pumped electro-luminescent material embedded within said light-emitting medium.

6. The chiral laser apparatus of claim 5, wherein said light-emitting medium comprises one of: rare earth doped material, chelated rare earth doped material, semiconductor materials, organic light-emitting materials, conjugated polymers, dye-doped material, and materials containing color centers.

7. The laser apparatus of claim 4, wherein said electromagnetic wave source comprises:

a diffuser having a plurality of edges and an emitting surface perpendicular to said plural edges; and

5 a tunable light-emitter configured for emitting electromagnetic radiation into at least one of said plural edges such that electromagnetic radiation is scattered and emitted from said emitting surface, said emitted electromagnetic radiation being dispersed along said emitting surface and being generally perpendicular to said periodic structure, and wherein when said emitted electromagnetic radiation is above said lasing threshold,  
10 said periodic structure only emits electromagnetic radiation at said predetermined frequency and having a wave vector substantially normal thereto.

8. The laser apparatus of claim 7, wherein said tunable light emitter comprises at least one LED strip positioned along and corresponding to said at least one  
15 plural edges, each of said at least one LED strips being tunable to provide variable light output.

9. The laser apparatus of claim 1, wherein said light-emitting medium is composed of a material adapted to emit electromagnetic radiation upon application of a  
20 charge current thereto, and wherein said variable excitation means comprises:

a plurality of electrodes connected to said periodic structure; and

a tunable electrical power source, connected to said plurality of electrodes for providing said charge current to the said periodic structure to excite said light-emitting medium to emit electromagnetic radiation.

5           10.    A passive spatial electromagnetic radiation filter apparatus comprising:

              a periodic structure having a top portion and a bottom portion of a thickness  $T$  and having an average refractive index  $N$ , said periodic structure being configured to produce a photonic mode of a predetermined frequency, said photonic mode being separated from a nearest lower frequency photonic mode by a frequency  
10   greater than determined in accordance with a following expression:  $c/2TN$ , wherein  $c$  is the speed of light in a vacuum; and

              a source for emitting electromagnetic radiation at said predetermined frequency within a cone that is generally perpendicular to said periodic structure through said periodic structure, wherein said periodic structure only transmits electromagnetic  
15   radiation of said predetermined frequency and having a wave vector substantially normal thereto, such that said electromagnetic radiation is passively spatially filtered as it passes through said periodic structure.

              11.    The passive spatial electromagnetic radiation filter of claim 10, wherein  
20   said photonic mode is one of a defect mode and a high frequency band edge mode.

12. An electromagnetic radiation amplifier apparatus comprising:

a periodic structure having a top portion and a bottom portion of a thickness  $T$  and having an average refractive index  $N$ , said periodic structure being configured to produce a photonic mode of a predetermined frequency, said photonic mode being separated from a nearest lower frequency photonic mode by a frequency greater than determined in accordance with a following expression:  $c/2TN$ , wherein  $c$  is the speed of light in a vacuum;

a light-amplifying medium disposed within said periodic structure and being configured to amplify electromagnetic radiation at said predetermined frequency;

an electromagnetic radiation source for emitting electromagnetic radiation at said predetermined frequency perpendicular to said periodic structure through said first surface of said periodic structure into said structure, such that a beam emerges through said second surface, wherein said periodic structure only transmits electromagnetic radiation of said predetermined frequency having a wave vector substantially normal thereto; and

variable excitation means, connected to said periodic structure, for applying gain of a selected magnitude to said periodic structure to thereby externally control a coherence area of said emerging beam, wherein said gain:

a) ranges from a lower gain to a higher gain,

b) is below a lasing threshold, and

c) is sufficient to provide amplification for said emitted electromagnetic radiation at said predetermined frequency such that when said gain is changed between said lower gain and said higher gain, said electromagnetic radiation emitted from said second surface is amplified and changed in coherence area corresponding to said change in said gain.

13. The electromagnetic radiation amplifier apparatus of claim 12, wherein said photonic mode is one of a defect mode and a high frequency band edge mode.

14. The electromagnetic radiation amplifier apparatus of claim 12, wherein said periodic structure comprises a plurality of dielectric material layers of at least two differing dielectric constants.

15. A method for producing large-area coherent lasing utilizing a periodic structure, comprising the steps of:

a) providing a periodic structure having a top portion and a bottom portion of a thickness  $T$  and having an average refractive index  $N$ , said periodic structure being configured to produce a photonic mode of a predetermined frequency, said photonic mode being separated from a nearest lower frequency photonic mode by a frequency greater than determined in accordance with a following expression:  $c/2TN$ , wherein  $c$  is the speed of light in a vacuum;

b) providing a light-emitting medium disposed within said periodic structure, said light-emitting medium being configured to emit electromagnetic radiation at said predetermined frequency; and

c) applying gain to said periodic structure, said gain ranging from a lower gain to a higher gain to cause said light-emitting medium to emit electromagnetic radiation in accordance with the magnitude of said gain when said gain exceeds a predetermined lasing threshold, such that wide-area coherence lasing at said predetermined frequency occurs in a direction perpendicular to said layered structure.

16. The method of claim 15, wherein said photonic mode is one of a defect mode and a high frequency band edge mode.

17. A method for passively spatially filtering electromagnetic radiation utilizing a periodic structure, comprising the steps of:

a) providing a periodic structure having a top portion and a bottom portion of a thickness  $T$  and having an average refractive index  $N$ , said periodic structure being configured to produce a photonic mode of a predetermined frequency, said photonic mode being separated from a nearest lower frequency photonic mode by a frequency greater than determined in accordance with a following expression:  $c/2TN$ , wherein  $c$  is the speed of light in a vacuum; and

b) emitting electromagnetic radiation, from an electromagnetic radiation source, at said predetermined frequency within a cone that is generally perpendicular to said periodic structure through said periodic structure, wherein said periodic structure only transmits electromagnetic radiation of said predetermined frequency and having a wave vector substantially normal thereto, such that said electromagnetic radiation is passively spatially filtered as it passes through said periodic structure.

18. The method of claim 17, wherein said photonic mode is one of a defect mode and a high frequency band edge mode.

19. A method for amplifying electromagnetic radiation utilizing a periodic structure comprising the steps of:

a) providing a periodic structure having a top portion and a bottom portion of a thickness  $T$  and having an average refractive index  $N$ , said periodic structure being configured to produce a photonic mode of a predetermined frequency, said photonic mode being separated from a nearest lower frequency photonic mode by a frequency greater than determined in accordance with a following expression:  $c/2TN$ , wherein  $c$  is the speed of light in a vacuum;

b) providing a light-amplifying medium disposed within said periodic structure and being configured to amplify electromagnetic radiation at said predetermined frequency;



c) emitting electromagnetic radiation, from an electromagnetic radiation source, at said predetermined frequency perpendicular to said periodic structure through said first surface of said periodic structure into said structure, such that a beam emerges through said second surface, wherein said periodic structure only transmits  
5 electromagnetic radiation of said predetermined frequency having a wave vector substantially normal thereto; and

d) applying gain of a selective magnitude to said periodic structure, from a variable excitation device, to thereby externally control a coherence area of said emerging beam, wherein said gain:

10 a) ranges from a lower gain to a higher gain,

b) is below a lasing threshold, and

c) is sufficient to provide amplification for said emitted electromagnetic radiation at said predetermined frequency such that when said gain is selectively changed between said lower gain and said higher gain, said  
15 electromagnetic radiation emitted from said second surface is amplified and changed in coherence area corresponding to said change in said gain.

20. The method of claim 19, wherein said photonic mode is one of a defect mode and a high frequency band edge mode.

21. The laser apparatus of claim 4, wherein said electromagnetic wave source comprises:

a diffuser having an emitting surface for contact with said periodic structure and back surface; and

5 a tunable light-emitter configured for emitting electromagnetic radiation into said back surface such that electromagnetic radiation is scattered and emitted from said emitting surface, said emitted electromagnetic radiation being dispersed along said emitting surface and being generally perpendicular to said periodic structure, and wherein  
10 when said emitted electromagnetic radiation is above said lasing threshold, said periodic structure only emits electromagnetic radiation at said predetermined frequency and having a wave vector substantially normal thereto.